AMENDMENTS TO THE CLAIMS

1-34. (Cancelled)

35. (New) A waveform equalization controller comprising:

a waveform equalizer operable to reduce a transmission line distortion of an input signal based on a LMS algorithm, and to output an output signal, wherein said waveform equalization controller is operable to control updating of a tap coefficient of a filter which is included in said waveform equalizer;

an error estimation unit operable to estimate an error of the output signal outputted from said waveform equalizer based on the output signal, and to output an error signal;

a step size decision unit operable to receive the error signal outputted from said error estimation unit and a step size upper limit value and a step size lower limit value, which are an upper limit value and a lower limit value of a step size as a step for updating the tap coefficient, respectively, to adaptively generate a step size corresponding to the error signal in a range of the step size upper limit value or smaller and the step size lower limit value or larger, and to output the generated step size; and

a coefficient updating calculation unit operable to calculate a tap coefficient amount based on the error signal outputted from said error estimation unit, the generated step size outputted from said step size decision unit, and a data to be used for updating the tap coefficient;

wherein said step size decision unit comprises:

a multiplier operable to square the error signal so as to generate and output a square error;

a square error storage unit operable to store a previous square error which has been generated at a previous tap coefficient update;

a subtracter operable to generate a difference between square errors, the difference between the square errors being a difference between the square error outputted from said multiplier and the previous square error stored in said square error storage unit;

a first comparator operable to compare the square error outputted from said multiplier with a first threshold;

a second comparator operable to compare the square error outputted from said multiplier with a second threshold;

a third comparator operable to compare an absolute value of the difference between the square errors with a third threshold;

a step size storage unit operable to store a previous step size which has been used at the previous tap coefficient update; and

a step size increasing/decreasing unit operable to receive the previous step size stored in said step size storage unit, an output of said first comparator, an output of said second comparator, an output of said third comparator, the step size upper limit value and the step size lower limit value, and to generate a step size which is to be used for updating the tap coefficient.

36. (New) The waveform equalization controller according to claim 35, wherein:

a value of the second threshold is such that when the square error is larger than the value of the second threshold, an operation of said waveform equalizer is trending toward divergence;

a value of the first threshold is such that when the square error is smaller than the value of the first threshold, the operation of said waveform equalizer is either converging or has converged;

a value of the third threshold is such that when the square error is smaller than the value of the first threshold,

the operation of said waveform equalizer is converging when an absolute value of the difference between the square errors is larger than the third threshold, and

the operation of said waveform equalizer has converged when the absolute value of the difference between the square errors is equal to or smaller than the third threshold; and

said step size increasing/decreasing unit is operable to

decrease the step size by a predetermined amount when it is judged from comparison results of said first to third comparators that the square error is larger than the second threshold,

decrease the step size by a predetermined amount when the square error is smaller than the first threshold and the absolute value of the difference between the square errors is equal to or smaller than the third threshold,

increase the step size by a predetermined amount when the square error is smaller than the first threshold and the absolute value of the difference between the square errors is larger than the third threshold, and

not change the step size in other cases.

37. (New) The waveform equalization controller according to claim 35, wherein:

a value of the second threshold is such that when the square error is larger than the value of the second threshold, an operation of said waveform equalizer is trending toward divergence;

a value of the first threshold is such that when the square error is smaller than the value of the first threshold, the operation of said waveform equalizer is either converging or has converged;

a value of the third threshold is such that when the square error is smaller than the first threshold,

the operation of said waveform equalizer is converging when an absolute value of the difference between the square errors is larger than the third threshold, and

the operation of said waveform equalizer has converged when the absolute value of the difference between the square errors is equal to or smaller than the third threshold; and

said step size increasing/decreasing unit is operable to

decrease the step size at a predetermined rate when it is judged from comparison results of said first to third comparators that the square error is larger than the second threshold,

decrease the step size at a predetermined rate when the square error is smaller than the first threshold and the absolute value of the difference between the square errors is equal to or smaller than the third threshold,

increase the step size at a predetermined rate when the square error is smaller than the first threshold and the absolute value of the difference between the square errors is larger than the third threshold, and

not change the step size in other cases.

38. (New) A waveform equalization controller comprising:

waveform equalizer means for reducing a transmission line distortion of an input signal based on a LMS algorithm, and for outputting an output signal, wherein said waveform equalization controller controls updating of a tap coefficient of a filter which is included in said waveform equalizer means;

error estimation means for estimating an error of the output signal outputted from said waveform equalizer means based on the output signal, and for outputting an error signal;

step size decision means for receiving the error signal outputted from said error estimation means and a step size upper limit value and a step size lower limit value, which are an upper limit value and a lower limit value of a step size as a step for updating the tap coefficient, respectively, for adaptively generating a step size corresponding to the error signal in a range of the step size upper limit value or smaller and the step size lower limit value or larger, and for outputting the generated step size; and

coefficient updating calculation means for calculating a tap coefficient amount based on the error signal outputted from said error estimation means, the generated step size outputted from said step size decision means, and a data to be used for updating the tap coefficient;

wherein said step size decision means comprises:

multiplier means for squaring the error signal so as to generate and output a square error;

square error storage means for storing a previous square error which has been generated at a previous tap coefficient update;

subtracter means for generating a difference between square errors, the difference between the square errors being a difference between the square error outputted from said multiplier means and the previous square error stored in said square error storage means;

first comparator means for comparing the square error outputted from said multiplier means with a first threshold;

second comparator means for comparing the square error outputted from said multiplier means with a second threshold;

third comparator means for comparing an absolute value of the difference between the square errors with a third threshold;

step size storage means for storing a previous step size which has been used at the previous tap coefficient update; and

step size increasing/decreasing means for receiving the previous step size stored in said step size storage means, an output of said first comparator means, an output of said second comparator means, an output of said third comparator means, the step size upper limit value and the step size lower limit value, and for generating a step size which is to be used for updating the tap coefficient.

39. (New) The waveform equalization controller according to claim 38, wherein:

a value of the second threshold is such that when the square error is larger than the value of the second threshold, an operation of said waveform equalizer means is trending toward divergence;

a value of the first threshold is such that when the square error is smaller than the value of the first threshold, the operation of said waveform equalizer means is either converging or has converged;

a value of the third threshold is such that when the square error is smaller than the value of the first threshold,

the operation of said waveform equalizer means is converging when an absolute value of the difference between the square errors is larger than the third threshold, and

the operation of said waveform equalizer means has converged when the absolute value of the difference between the square errors is equal to or smaller than the third threshold; and

said step size increasing/decreasing means

decreases the step size by a predetermined amount when it is judged from comparison results of said first to third comparator means that the square error is larger than the second threshold,

decreases the step size by a predetermined amount when the square error is smaller than the first threshold and the absolute value of the difference between the square errors is equal to or smaller than the third threshold,

increases the step size by a predetermined amount when the square error is smaller than the first threshold and the absolute value of the difference between the square errors is larger than the third threshold, and

does not change the step size in other cases.

40. (New) The waveform equalization controller according to claim 38, wherein:

a value of the second threshold is such that when the square error is larger than the value of the second threshold, an operation of said waveform equalizer means is trending toward divergence;

a value of the first threshold is such that when the square error is smaller than the value of the first threshold, the operation of said waveform equalizer means is either converging or has converged;

a value of the third threshold is such that when the square error is smaller than the first threshold,

the operation of said waveform equalizer means is converging when an absolute value of the difference between the square errors is larger than the third threshold, and

the operation of said waveform equalizer means has converged when the absolute value of the difference between the square errors is equal to or smaller than the third threshold; and

said step size increasing/decreasing means

decreases the step size at a predetermined rate when it is judged from comparison results of said first to third comparator means that the square error is larger than the second threshold,

decreases the step size at a predetermined rate when the square error is smaller than the first threshold and the absolute value of the difference between the square errors is equal to or smaller than the third threshold,

increases the step size at a predetermined rate when the square error is smaller than the first threshold and the absolute value of the difference between the square errors is larger than the third threshold, and

does not change the step size in other cases.

41. (New) A waveform equalization control method for controlling updating of a tap coefficient of a filter which is included in a waveform equalizer for reducing a transmission line distortion of an input signal based on a LMS algorithm, said method comprising:

estimating an error of an output signal outputted from the waveform equalizer based on the output signal, and generating an error signal;

adaptively deciding, based on the error signal generated in said generating of the error signal, a step size in a range of a step size upper limit value, which is an upper limit value of a step size as a step for updating the tap coefficient, or smaller, and a step size lower limit value, which is a lower limit value of the step size, or larger; and

calculating a tap coefficient updating amount based on the error signal generated in said generating of the error signal, the step size decided in said adaptively deciding of the step size, and a data to be used for updating the tap coefficient;

wherein said adaptively deciding of the step size comprises:

squaring the error signal so as to generate and output a square error;

generating a difference between square errors, which is a difference between a previous square error generated at a previous tap coefficient update and the square error generated in said squaring of the error signal;

comparing the square error generated in said squaring of the error signal with a first threshold;

comparing the square error generated in said squaring of the error signal with a second threshold;

comparing an absolute value of the difference between the square errors with a third threshold; and

generating a step size which is to be used for updating the tap coefficient based on a previous step size which has been used at a previous tap coefficient update, a comparison result of said comparing of the square error with the first threshold, a comparison result of said comparing of the square error with the second threshold, a comparison result of said comparing of the absolute value of the difference between the square errors with the third threshold, the step size upper limit value and the step size lower limit value.